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TRANSLATION

A DEVICE FOR THE DETERMINATION OF CORE FREQUENCY PROPERTIES
IN THE RE-MAGNETISATION PROCESS ALONG HYSTERESIS SYMMETRIC
CYCLES CLOSE TO A LIMITING HYSTERESIS LOOP

By

E. F. Berezhnoy

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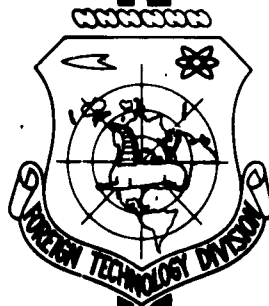
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A DEVICE FOR THE DETERMINATION OF CORE FREQUENCY PROPERTIES
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Institut Tochnoy Mekhaniki i Vyshislitel'noy Tekhniki
Akademii Nauk SSSR

PRIBOR DLYA OPREDELENIYA CHASTOTKHYKH SVOYSTV SERDECHNIKOV
PRI PEREMAGNICHIVANII PO SIMMETRICHNYM
TSIKLAM GISTEREZISA, VLIZKIM K PREDEL'NYM

A DEVICE FOR THE DETERMINATION OF CORE FREQUENCY PROPERTIES IN THE RE-MAGNETISATION PROCESS ALONG HYSTERESIS SYMMETRIC CYCLES CLOSE TO A LIMITING HYSTERESIS LOOP

E. F. Berezhnoy

In the evaluation properties of magnetic cores used in switching circuits of automatic devices and computing techniques, an important role is played by the functions which show the nature of the change in the output signal of the core, in connection with a change of the frequency of its re-magnetisation process in the pulse rates along the cycles close to a limiting loop. The necessity of determining the characteristics of this kind is dictated by the following considerations. The dissipation of thermal energy in the body of the core in a real system brings about an increase in its temperature and a corresponding change of magnetic properties. Property changes are expressed in the change in amplitude and pulse form e.m.f. on the outgoing coil of the core with a change of the remagnetisation frequency and of other invariable conditions. Thus the upper limit of the working frequency band is determined along with the limitation in speed of the pulse remagnetisation of the core, as well as the limitation of frequency of remagnetisation by the temperature resultant affecting the magnetic properties. Especially essential is the knowledge of the frequency-temperature relations for materials with a low value Curie point or with high specific losses on remagnetisation. A comparison of the frequency- temperature relationship with a direct measurement of the temperature of the core gives a criteria for the evaluation of the construction of the core (material and geometry of the casing, the thickness of the inter-coil insulation, the affect of possible overflow, etc.).

Frequency-temperature relations cannot be replaced by those temperature characteristics of the cores, which are determined

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by means of heating up the core from an outside-thermal source and its remagnetisation by single impulses. Such characteristics show the change of magnetic and impulse properties in relation with the temperature. However, they do not contain the data about the magnitude of the excess of the core temperature over the surrounding agents, conditioned by the losses in the core with the concrete conditions of the remagnetisation.

The device described below, allows for the determining of the frequency and frequency-temperature relations of ferrite and band magnetic cores at remagnetisation frequency intervals from 10 to 1000 kilocycles. With regards to the core under investigation, the apparatus is a two channel source of rectangular current pulses of regulated length and amplitude, having a porosity in each channel equal to two.

A diagram sketch of the device is presented in Fig. 1, a principle sketch is given in Fig. 2[a]. The symmetrical multivibrator Mv, accomplished by pentodes 6P15P, gives an output fixing the remagnetisation frequency of the core. The interval of the remagnetisation frequencies is secured by a device split into two bands: from 10 to 100 kilo, and from 100 to 1000 kilo. The switching over from one band frequency to the other is brought about by a switching of the changeover capacitors in the circuits of the first tube grids of the multi-vibrator (tumbler switch Tb. 8); a continuous change of frequency within the limits of the band is achieved by a change of resistances in the circuits of the changing over discharge capacities and by a change in the setting of the discharge voltage variable resistances R_{19} and R_{21}). Oscillation from the anode of the multivibrator tube
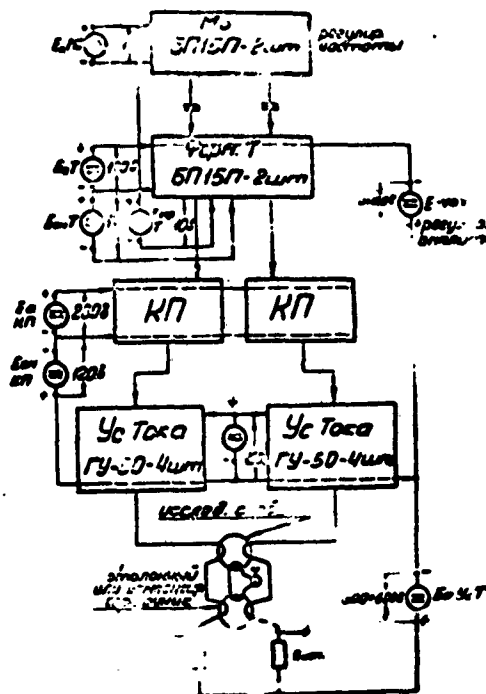
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Fig. 1. A diagram sketch of a stand of frequency characteristics

is coupled through the differentiating R-C circuits into a third network of tubes (trigger T), which generates signals with front steepness, for practical purposes independent of the frequency, and without an inclination of the flat top. The trigger is thrown over from one state to another by the negative pulse, entering from the differentiating circuit to the suppressor grid of the conducting tube and effecting the beginning of the process of its cutting off. At the same time a positve pulse enters the suppressor grid of the cutoff tube through the R-C circuit from a different anode of the multivibrator. This speeds up the switching of the trigger into a new stable condition. Other elements are introduced into the trigger circuit, promoting an increase of the front steepness of the signal at the circuit outlet.

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D - Д
L - Л
N - Н
Z - З
I - И
U - У
G - Г
Zh - Ж
R - Р
P - П
B - Б
S - С

Studied core - исслед. серд.
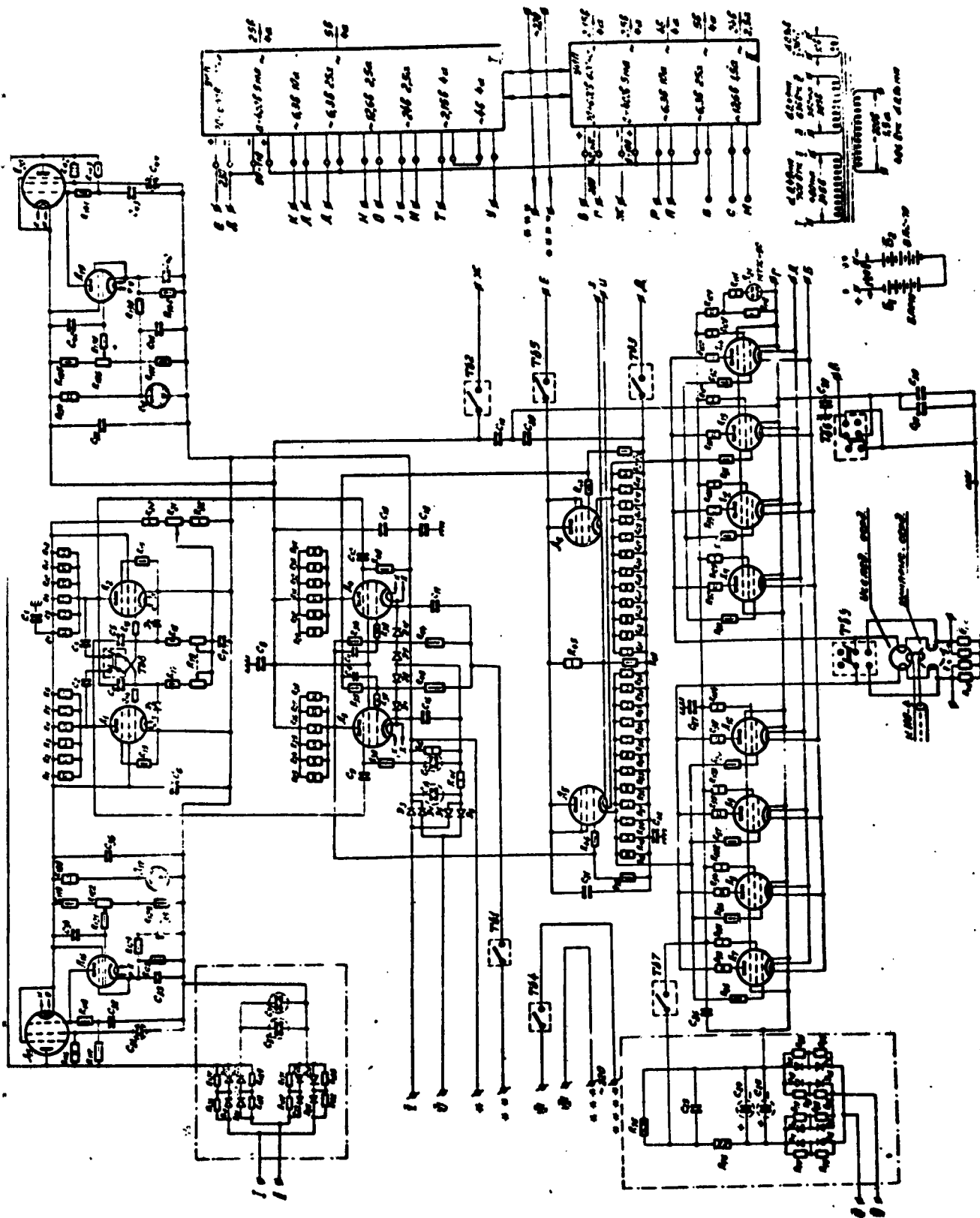Compens. core- компенс. серд.

Fig. 2

The anodes of the tubes are connected with the first grids of the cathode followers (KP), provided by the tubes GU-50 in the triode connected configuration. The outputs of the cathode followers are each connected separately to the in-puts of the tubes of the output stages. The amplifiers form a two-cycle circuit in relation to the core under investigation, each leg of which consists of four GU-50 type, working in a pentode system.

Two magnetising coils with the same number of turns, and a measuring coil were applied to the core under investigation. Each of the magnetising coils is hooked into the leg of the output current amplifiers. The measuring coil is connected to the "Y" input of a series oscillograph, type IO-4 or UO-1M, used as a measuring component of the described device. The amplifier vertical deflection of the oscillograph is calibrated according to sensitivity, after which the amplitude of the output signal of the core is determined by the magnitude of the (ray) deflection on the screen of the oscillograph. The amplitude of the magnetising current is measured by the drop in voltage on the measured resistances $R_{meas.}$ = 5 ohms, connected in series with the magnetising coils.

In investigating cores with small magnetic fluxes, when the signal of the direct link by air between the magnetisation coils and the computing coil is of the same order as the signal from the core magnetisation, additional compensating coils are hooked into the circuit wound onto a covering, similar to the covering of the core being investigated. The compensating measuring coil is connected to the measuring coil of the core under

investigation, and the current compensatory coil is hooked in series with the remagnetisation coils. In this case, the signals of the direct link between the current and measuring windings are reduced to a significant degree.

In connection with the fact that it is extremely undesirable to apply a constant voltage in any amount significantly differing from the frame potential of the device, the anode bar of the output stages (and one end of the measuring resistances) is grounded, and the cathodes of the output tubes are connected to a negative voltage. The connections from the stages to the magnetizing coil are direct, which makes significantly easier the task of obtaining an even waveshape characteristic over a wide frequency band. Two stabilized power sources UIP-1, and also two electronic stabilizers arranged on the chassis of the device, two unstabilized rectifiers and an anode battery are used in the system of feeding the stages of the device. The feed is divided into two separate parts: power supply Mv and T and feed KP (CP) of the output stages. Both groups of feed sources are independent and are connected with one another through a regulated voltage source "amplitude regulator." With a decrease in the absolute voltage magnitude of this source, the anode potential of the trigger approximates the cathode potential of the output tubes, the total amplitude of the signal grows on the first grid and the amplitude of the current pulses increases in both channels. A separate current amplitude control for each channel is not provided.

The counter e.m.f. induced in the current widnings with remagnetisation of the core is subtracted from the voltage of the anode

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feed of the output stages, lowering the voltage of the anode-cathode of tubes GU-50 and, at the same time, decreasing the magnitude of the remagnetising current. Thanks to the pentode characteristic of the output tubes, the magnitude and form of the remagnetising current for all practical purposes are not related to the parameters of the core in question (for the measurement of the cores used in the switching currents), i.e., the device comes close in characteristics to the ideal current source. The output resistance forms about 5000 ohms along each of the channels. However, for working the tubes on the horizontal section of the anode characteristic, the source of the anode feed should place the voltage of the band of the pentode characteristic of tube GU-50. At that time the force, separated on the anodes of the output tubes increases with the increase of voltage of the anode feed. Therefore, the magnitude of the voltage of the source of the anode feed of the output stages is regulated, during the testing of the cores, in relation to their overall gage and the observed speed of the remagnetisation within 250-600^a (v) with a visual control of the form of the remagnetising current of the oscillograph.

The relation of the amplitude of the currents in the channel with the remagnetisation frequencies at three different settings of voltage source is cited in fig. 3. The irregularity of the frequency characteristic of the current does not exceed ± 5%. The oscillograms of the waveform of one of the channels' current are illustrated in fig. 4. The rise-time of the waveform is almost 0.15 ucsec.

The method of determining the frequency characteristics of the cores, with the aid of the described device, and the

diagrammatic operation of these characteristics are described in
job (1). In fig. 5 are cited the relations of the output signal
amplitude of the core (in volts per turn) from remagnetisation
frequencies for two cores of a super thin metal ribbon of alloys
with a rectangular hysteresis loop of the type 34 NKMP and 79 NMA.
The amplitude value of the remagnetisation field in relation to
the coercive force of the material of the core (the so-called
"forcing") is indicated near each curve. Here are recorded the
rises of the surface temperature of the band over the temperature
of the surrounded elements, received by directly measuring the
temperature with a nichro-constantan thermo-couple. The basic
constructive parameters of the cores (the average diameter of
the core dcp; width of the band h; number of turns of band n;
the type of protective enclosure) are indicated in the figures.
The cited characteristics give a notion of the nature of the
tangible, observed relations and of the role of thermal effects
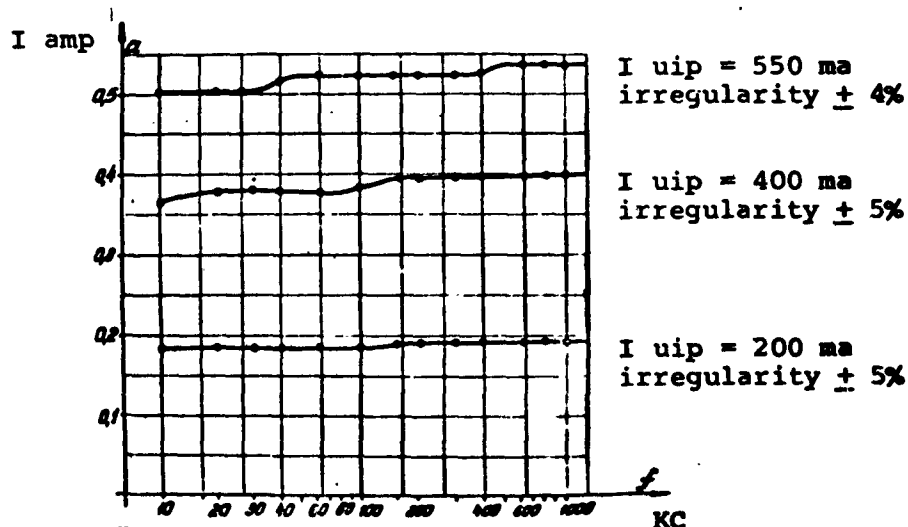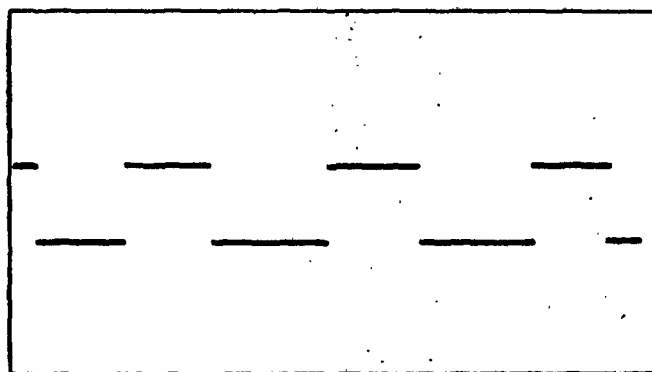during the working of the cores in a wide frequency band.

I uip = 550 ma
irregularity ± 4%

I uip = 400 ma
irregularity ± 5%

I uip = 200 ma
irregularity ± 5%
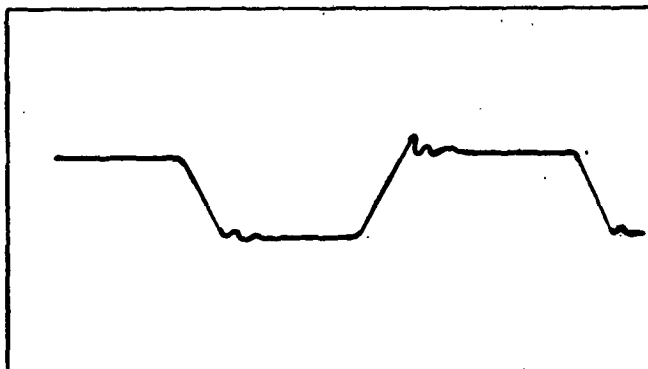
Fig. 3

Fig. 4. Oscillograms of the signal on one of the
channels the measured resistance
$R_{meas.}$ = 5 ohm.

     (a) - frequency of pulses 50 kilocycles/sec.
     (b) - frequency of pulses 300 kilocycles/sec.
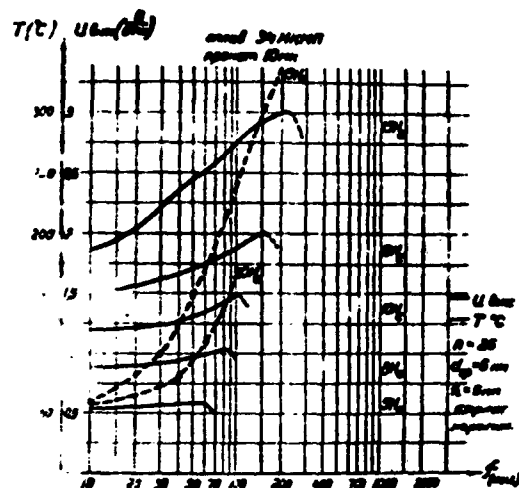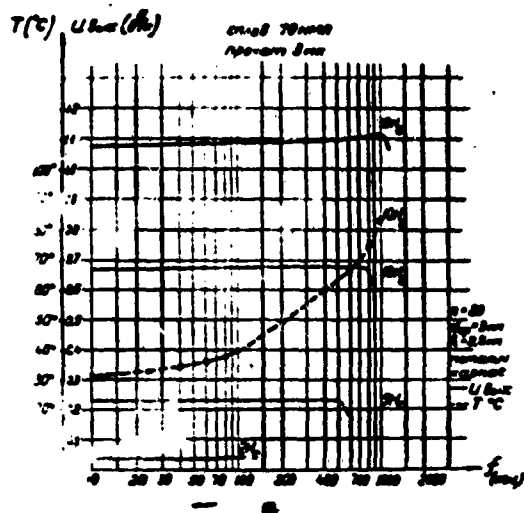
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Fig. 5.   Frequency characteristics of toroidal magnetic
cores of the bands of a super-thin roll with a
rectangular hysteresis loop:

(a)   the core of an alloy band, type 79 NMA,
with a thickness of 3 mc;

(b)   the core of an alloy band, type 34 NCMP,
with a thickness of 10 mc.

A useful addition to the device is a series of contact jigs
doing away with the necessity of manual winding during the testing
of single layer cores. The external appearance of one of this
type of nodes, intended for testing the cores of metal bands on a
ceramic form or one of the ferrite cores, is shown in figure 6.
The contact node has two contact knobs, one of which is shown in
a closed condition, and the other in an opened condition. The core
is placed into a vertical bar (1) in the center of the knob, consis-
ting of four silver wires connected into a single unit by epoxy
resin. The resin isolates the wires from each other. After splic-
ing the outer cylindrical surfaces of the wires, they are milled
until they are flat, so that each of the four wires acquires the
form of a half-circle in the cross-section. The moving (upper)
Part 2 - cont.
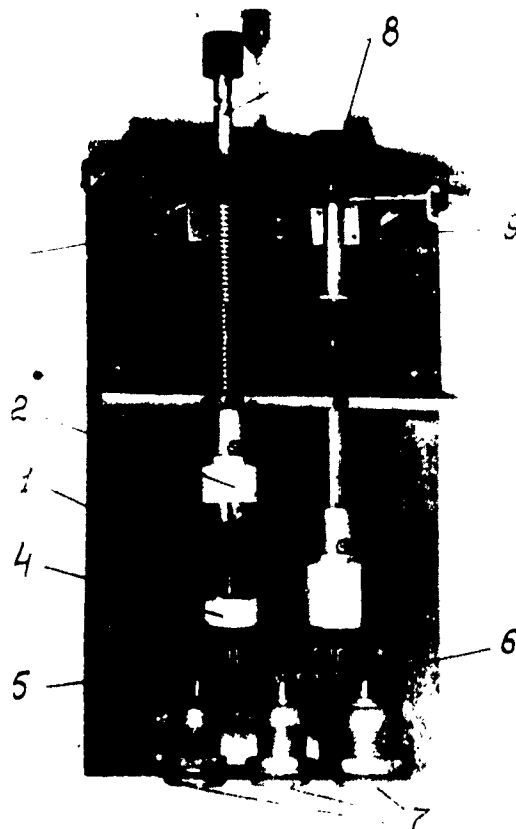
of the contact knob carries four jump bridge contacts of beryllium
bronze, each of which joins, on closing the knob, one of the four
segments of the central bar with the immobile contact, situated
inside the frame (4) of the knob. By joining the outlets of the
contacts and the central bar, it is possible to create the desired
circuit on the coils in question. In the given case, it is con-
venient to have two single-turn magnetising coils and a double-
turn measuring coil. (In fig. 6, the electronic connections are
absent.) The coils of the contact node are connected to the device
through terminals of a 14-contact telephone connector (6), and with
the measuring oscillograph, through a coaxial connector (7). The
contact node is set directly on the device in a vertical position.
The contact posts (8) are held in the lower switching-on position
by catch devices mechanically interlocked with microcut-off (9)
switches, which break the anode feed circuit of the output tubes
of the device before opening the contact knob, warding off
electrocorrosion of the knob contacts and taking the voltage
away from the coils.

The basic technical characteristics of the device

1. Frequency of pulses of the remagnetising   10÷ 1000 kc/sec
   current

2. Amplitude of current pulses along one   150÷ 550 ma
   channel

3. Number of current channels - two

4. Length of front of remagnetising current   0.12÷ 0.15mc sec.

5. Maximun possible value of the counter-   400 *voltes*
   e.m.f. on the remagnetising coil

6. Output resistance of the device along   ~ 5000 ohms
   each of the channels

The basic data of the contact nodes series

Type of	No. of conductors in central rod. post.	Overall sizes of core, mm		
		minimum diameter of aperture	maximum external diameter	maximum height
1 (fig.6)	4	2	7	8
2	8	3.5	10	9
3	12	6	13	10

SPECIFICATION OF COMPONENTS

OF THE MAIN DIAGRAM OF THE DEVICE

Column 1

Л1 -Л4	6П15П
Л5 -Л15	ГУ-50
Л16,Л19	6Ж1П
Л17,Л18	СТ2П
Л20	ГУ-50
Л21	МТХ-90
R1 -R12	5,6 ком
R13,R15	1,2 ком
R14,R16	360 ом
R17,R18	16 ком
R19	100 ком
R20	11 ком
R21	68 ком
R22	6,8 ком
R23 -R34	5,6 ком
R35,R36	39 ком
R37,R38	120 ом
R39,R40	1,1 ком
R41	6,8 ком
R42	3,9 ком
R42,R44	51 ком
R45	68 ком
R46,R47	120 ом
R48 -R59	4,7 ком
R60	150 ком
R61 -R72	4,7 ком
R73,R74	1 мегом
R75,R76	2 ком
R77 -R84	51 ком

Column 2

R85-R92	510 ом
R93-R100	100 ом
R101 R102	430 ом
R109	10 ком
R110	18 ком
R111	68 ком
R112-R115	10 ом
R116	2,4 ком
R117	100 ком
R118	510 ком
R119	120 ком
R120	6,2 ком
R121	300 ком
R122	68 ком
R123-R125	68 ком
R126-R133	51 ком
R134	6,2 ком
R135	120 ком
R136	68 ком
R137	68 ком
R138	300 ком
R139,R140	68 ком
R141	510 ком
R142	2,4 ком
R143	100 ком
C1	7500 пф
C2,C3	300 пф
C4,C5	30 пф
C6	0,05 мкф

Column 3

C7	1 мкф
C8	1000 пф
C9 -C12	30 пф
C13	0,05 мкф
C14,C15	10 мкф
C16	6800 пф
C17	1 мкф
C18	2000 пф
C19,C20	1 мкф
C21	10 мкф
C22	0,02 мкф
C23	10 мкф
C24,C25	20 мкф
C26	0,05 мкф
C27,C28	0,02 мкф
C29,C30	4 мкф
C31	20 мкф
C32,C33	0,05 мкф
C34,C35	0,1 мкф
C36,C39	10 мкф
C37,C38	20 мкф
C40,C41	0,1 мкф
C42,C43	0,05 мкф
C44	20 мкф
Д1,Д2	ДГ-Ц
Д3 -Д6	ДГ-Ц3
Д7 -Д10	ДГ-Ц
Д11-Д26	Д7Б

Л = L (Tube, V)
П = P
Ж = zh
С = S
Г = G
Х = kh
Д = D (Diode)

ом = ohms
ком = com Kilohm
мегом = megohm
пф = micromicrofarad
мкф = microfarad

FOOTNOTE

a) The specification for the main diagram is given in the appendix.

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